Alcohol and trauma:

The impact of acute and chronic alcohol abuse on injury severity and death in a trauma population

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ABSTRACT

Study objectives: To explore possible impact of acute and chronic alcohol abuse on injury severity and mortality in male and female trauma patients.
Design: A prospective cohort study.
Setting: Regional Level 1 trauma center in Seattle, Washington, USA.
Participants: 2195 men and 664 women 18 years or older, admitted with blunt or penetrating trauma.
Main results: The effect of alcohol use on injury severity and mortality was different between genders. Increasing use of alcohol in men showed a "protective" effect, while the opposite effect was observed in women. With the exception of injury severity in motor vehicle occupants and motorcyclists, the "protective" effect of alcohol was found for all types of trauma in men, whereas increasing alcohol use in women was associated with an increase in injury severity and mortality for penetrating injuries and for motor vehicle occupants and motorcyclists. Women with blunt injuries, however, showed the same "protective" effect from alcohol as observed in men. No differences was found between acute and chronic alcohol use with respect to trauma morbidity and mortality.
Conclusion: This study indicates that acute and chronic alcohol use, at least for some types of injury, has contrasting effects on injury severity and mortality in men and women hospitalized for trauma. Future studies on alcohol and trauma should recognize this, and present sex-specific analyses.

Key words: alcohol markers; biological; injury severity; lethality; screening tests; trauma

Abbreviations: AIS (Abbreviated Injury Scale); BAL (blood alcohol level); GDH (glutamate dehydrogenase); GGT (gamma-glutamyltransferase); HMC (Harborview Medical Centre); ISS (Injury Severity Score); MCV (mean corpuscular volume); MV-occupants (motor vehicle occupants); SMAST (Short Michigan Alcohol Screening Test); WAM (weighed alcohol markers).

INTRODUCTION

The association between alcohol use and injury has long been recognized. Alcohol is reported to be implicated as a contributing factor in marital violence, suicides, homicides, stabbings, occupational injuries, and traffic accidents (1-3). As for the consequences of trauma, like injury severity and trauma death, the literature has been more conflicting (4-10). Some studies have demonstrated a potentiating effect of acute alcohol intoxication on the injury severity and the risk of death (4-7), other studies fail to find significant evidence for such relations (8-9). Some authors have even postulated that alcohol has a protective effect in trauma with higher survival rates in the alcohol group (10). Based on a cohort of trauma patients admitted to hospital treatment, this study evaluates the relationship between:

1) alcohol use and injury severity,
2) alcohol use and death due to trauma.

Alcohol use in this study is described in degrees of blood alcohol level, degrees of elevation in biological alcohol markers, and by responses to alcohol questionnaires. As none of the published papers on this topic give separate analyses for the different genders, we chose to do the analyses gender-specific.

MATERIAL AND METHODS

The study population consisted of 2823 subjects (2159 men and 664 women), aged 18 years or older with blunt or penetrating trauma hospitalized at Harborview Medical Center (HMC) in Seattle, Washington, between March 1989 and February 1991. HMC is a Level I regional trauma center in the King County in Washington (more than 2 million inhabitants), and cares for for the great majority of seriously injured patients (89.5% during the study period were treated at HMC) in the region.

Non-admitted trauma patients, patients with a hospital stay of less than one day, and patients with the following injuries were excluded from the study: hanging or suffocation; drowning or near-drowning; burns; electrocutions; primary hypothermia; and poisoning. Due to personnel limitations, the patients admitted and discharged over the same weekend (unless they died) were also excluded, and a second time enrollment of re-admitted study patients was prevented.

Blood samples were drawn for measurements of some of the most frequently used biological markers of alcohol problems. These markers were; blood alcohol level (BAL), gamma-glutamyltransferase (GGT), and mean corpuscular volume (MCV). When not used as continuous variables, BAL (mg/dl) was categorized as; 1) negative, 2) 1-99, 3) 100-199, 4) 200-299, and 5) ≥300. For GGT the categorization was determined (low, high) according to the laboratory standards for Harborview Medical Center, adjusted for sex and age. For MCV the hospital laboratory ranges were used, low MCV was defined as up to 99 mm^3. To assess the degree of alcohol problems, a scale ranging from 0 to 24 was established by combining three of the markers (BAL, GGT, and MCV) giving them different weights ("WAM-scores"). When stratified, low was defined as <7 scores for men and <6 scores for women (see ref.11 for further information on "WAM-scores"). In addition, each subject completed the 13-item short form of the Michigan Alcohol Screening Test (SMAST), from January 1990 also the CAGE questionnaire (1088 men and 352 women, respectively). The SMAST and CAGE were used because they represent the two most often reported and validated alcohol screening instruments for medical populations. The structured SMAST-interview is used as a screening tool to detect behavioral correlates of alcoholism; it focuses on consequences of problem drinking and the subjects' own perceptions of their alcohol problem (12). Three or more positive responses indicate that the subject has significant alcohol problems (13). The CAGE test comprises 4 items; ≥2 positive responses are considered indicative of significant alcohol problems (14).

We also measured glutamate dehydrogenase (GDH), but as this enzyme also is positively related to tissue damages and to acute circulation disturbances, we found it less useful for a trauma population, and excluded it from further analyses.

A patient's Injury Severity Score (ISS) was calculated using the 1985 Abbreviated Injury Scale (AIS) (15), which was derived from up to ten discharge ICD-9-CM codes using the ICD-MAP PC computer program (16).

Trauma etiology were registrated for each patient. For some of the analyses trauma etiology were categorized as:

1. Penetrating (stab, handgun, rifle, shotgun, gunshot wound (GSW) unspecified, and other penetrating traumas)
2. Traffic accident (Motor vehicle occupant, motorcyclist)
3. Blunt (pedestrian, bike, fall, blunt, sport, other)

Statistical calculations were performed using the Statistical Package for the Social Sciences (17), including chi-square test, Student's *t*-test, and Spearman's rank correlation when appropriate.

RESULTS

Mean age was 35.4 years for men and 40.0 years for women. More than 50% were younger than 35 years, and only 5% were older than 65 years. Thirty-two percent of the women and 51% of the men had measurable alcohol in serum, and 23.2% and 40.1% of women and men were intoxicated (BAL ≥100 mg/dl). Mean ISS were 13.4 and 13.8 for men and women, respectively. A total of 243 patients died, of which 187 (8.7%) were men and 56 (8.4%) were women.

In both sexes, motor vehicle (MV) occupants and pedestrians constituted the largest number of fatal traumas in total, whereas injuries from different firearms (penetrating) displayed the highest percentage of fatal issues within the single groups (Table 1).

In men, the different indicators of acute and chronic alcohol drinking showed higher mean values for those who survived than for those who died (Table 2). When these variables were dichotomized as "low" versus "high", men with low values showed the highest mean ISS and the highest percentage mortality (Table 3). Analysis of ISS and mortality for different levels of blood alcohol concentration displayed a significant decreasing trend in both variables by increasing levels of intoxication (Table 4). Intoxicated

Table 1. Sex-specific numbers of fatal traumas (n) with percent (%) for different etiologies.

	Men		Women	
Trauma	n	%	n	%
Stab	6	2.7	1	3.5
Handgun	24	21.1	6	24.0
Rifle	6	37.5	–	–
Shotgun	3	13.6	–	–
Gsw. unspecific*	16	27.1	2	18.9
Other penetrations	–	–	–	–
MV-occupants**	45	8.3	23	6.5
Motorcyclists	14	6.6	–	–
Fall	21	6.3	11	12.0
Pedestrians	28	20.3	11	17.0
Blunt	19	5.3	1	2.3
Bike riders	3	7.9	–	–
Sport	–	–	–	–
Other	2	11.8	1	20.0

* General shooting weapon
** Motor vehicle occupant

Table 3. Sex-specific mean (x) with standard deviation (sd) of injury severity score (ISS) and percentage trauma death (%) according to normal and elevated alcohol indicators.

	ISS				Trauma death	
	Men		Women		Men	Women
	x	sd	x	sd	%	%
BAL						
<100	‡13.9	10.1	13.9	10.5	‡10.1	8.0
≥100	12.6	11.2	13.7	11.2	6.5	9.7
WAM						
<7 (6)	‡14.1	10.3	14.2	10.7	†9.8	7.9
≥7 (6)	12.2	9.7	13.0	10.5	6.8	9.5
GGT						
Low	‡13.6	10.1	14.1	10.3	9.3	8.0
High	11.8	10.1	12.5	10.8	8.3	9.5
MCV						
Low	‡13.5	10.2	13.9	10.7	8.8	8.5
High	10.9	9.1	11.8	8.7	6.6	6.5
SMAST						
<3	‡12.9	9.2	†13.0	9.2	2.3	1.0
≥3	11.3	8.3	11.4	8.9	1.2	1.7
CAGE						
<2	†13.1	9.4	13.4	9.7	2.1	1.3
≥2	11.1	8.4	11.8	8.9	0.8	2.7

‡ $p<0.01$ † $p<0.05$ (significant difference in mean values).

male MV-occupants and motorcyclists (Table 5) showed a slightly higher (but non-significant) mean ISS compared with those who were not intoxicated. For the two other categories of trauma etiology (penetrating and blunt) intoxicated men displayed lower mean ISS compared to non-intoxicated. For all three categories of trauma etiology, the mortality percentages were higher for non-intoxicated than for intoxicated men.

In women, the results showed the opposite trend; fatally injured women had higher mean values for the different alcohol indicators than those who survived. Only mean CAGE- and SMAST-scores were negligibly smaller among those who died (Table 2). There was a higher percentage trauma death among women with "high" values for BAL, GGT, WAM, SMAST and CAGE (except for MCV) compared to women with normal values (Table 3), but none of these differences were significant. On the other hand, women with normal values for the different alcohol markers showed an non-significant higher injury severity compared with women with abnormal values.

There was no significant trend for change in ISS by increasing levels of intoxication in women (Table 4). An increase in mortality was observed with increasing intoxication, but the increase was not significant.

Penetrating (stab, firearms) traumas together with MV and motorcycle accidents displayed higher injury

Table 2. Means (x) and standard deviations (sd) for gamma-glutamyltransferase (GGT), mean corpuscular volume (MCV), blood alcohol level (BAL), weighted alcohol markers (WAM), CAGE and SMAST in the patients who were discharged alive from hospital and who died in hospital.

	Men (n=2159)				Women (n=664)			
	Alive (n=1972)		Died (n=187)		Alive (n=608)		Died (n=56)	
	x	sd	x	sd	x	sd	x	sd
GGT	42.3	128.1	41.5	74.2	28.3	65.5	36.4	71.9
MCV	90.6	6.0	90.6	4.9	90.0	6.2	91.3	4.8
BAL	100.4	122.9	65.9	104.0	55.4	100.8	57.8	105.9
WAM	5.9	6.0	4.9	5.2	4.2	5.0	5.1	5.8
CAGE*	0.9	1.2	0.1	0.5	0.5	1.0	0.2	0.8
SMAST	3.8	4.0	0.5	2.1	2.4	3.0	0.5	2.1

* Reduced sample size

Table 4. Sex-specific means (x) with standard deviations (sd) for injury severity score (ISS) and percentage trauma death (%) according to different levels of blood alcohol concentrations.

	Blood alcohol levels (mg/dl)									
	Negative		1–99		100–199		200–299		≥300	
	x	sd	x	sd	x	sd	x	sd	x	sd
ISS										
Men	14.1	10.4	13.4	9.6	14.3	10.5	12.1	9.2	9.8	8.9‡
Women	13.9	10.2	13.7	12.7	14.8	12.2	12.8	9.9	12.3	10.9
Death										
Men	10.5%		8.7%		8.7%		4.9%		4.7%‡	
Women	8.6%		3.5%		11.1%		7.6%		10.3%	

‡ $p<0.01$, Significant for trend

Table 5. Means (x) with standard deviations (sd) for injury severity score (ISS) and percent trauma death in non-intoxicated (NI; BAL < 100 mg/dl) and intoxicated (I; BAL ≥ 100 mg/dl) subjects according to different trauma groups.

	ISS				Trauma death	
	NI		I		NI	I
	x	sd	x	sd	%	%
Men						
Penetrating (n = 505)	11.1	8.8	10.8	8.9	†12.8	8.5
Motor traffic (n = 752)	15.7	10.8	16.2	10.7	8.2	7.2
Blunt (n = 902)	‡13.9	10.2	11.0	9.0	‡10.4	4.7
Women						
Penetrating (n = 79)	12.1	11.1	12.9	9.3	6.9	†23.8
Motor traffic (n = 371)	14.3	10.6	17.0	12.4	5.4	9.3
Blunt (n = 214)	‡13.8	10.1	9.6	8.6	†13.5	5.2

† Significant difference, $p<0.05$
‡ Significant difference, $p<0.01$

severity for intoxicated women compared to non-intoxicated. Intoxicated women with penetrating traumas also showed a significant increase in mortality. By contrast, intoxicated women with blunt traumas had lower mean value for ISS, and lower percentage mortality compared to non-intoxicated (Table 5).

Even by equal degree of injury severity (stratified ISS), high and low values for the alcohol markers showed differences in percent mortality (data not shown). Men with high values showed lower percentage mortality, whereas women showed the opposite trend. However, none of these differences were significant.

DISCUSSION

This study evaluates the relationships between alcohol use and the severity of injury and mortality in a large sample of trauma patients admitted to a Level 1 trauma center. In contrast to other studies, this study includes indicators of both acute and chronic alcohol use, and gender-specific analyses were conducted.

Indicative of acute alcohol abuse is a positive blood alcohol concentration. Salaspuro (18) states that "BAL is the most obvious and specific test for alcoholism and problem drinking in trauma populations". According to NCA (National Council on Alcoholism), blood alcohol exceeding 150 mg/dl without evidence of intoxication, over 300 mg/dl at any time, or over 100 mg/dl on routine examination, are first level criteria for a diagnosis of alcoholism (19).

Chronic alcohol abuse may include elevation in GGT (20) and/or MCV (21). The weighted combination of BAL, GGT, and MCV, the "WAM-scores" (11), represent a strong indicator for alcohol abuse of both acute and chronic type in trauma populations. Pointing at behavioral consequences of problem drinking, the SMAST (12-13) as well as CAGE (14) serves as indicators of chronic alcohol abuse.

Our analyses indicate a sex-specific difference in the relation between alcohol use and trauma consequences. This is, in fact, an interesting finding, especially as other studies have failed to demonstrate corresponding results. The consequent lack of gender-specific analyses in other studies may represent one possible explanation for the conflicting conclusions in published papers.

Acute alcohol abuse (high or increasing BAL) was, in men, associated with significantly lower (or decreasing) values for ISS and trauma death (Tables 2-4). The mortality in women increased non-significantly by increasing intoxication, whereas ISS was unaffected by degree of alcohol level (Table 4).

A classification of trauma type revealed that intoxicated MV-occupants and motorcyclists (Traffic accidents) showed no significant differences in mean ISS and percent death for either of the sexes compared to those non-intoxicated (Table 5). The majority of published studies dealing with traffic injuries (2,4,6-8) conclude that alcohol use has a major impact on injury severity and mortality. Although our analyses do not show any significant differences, the trend found in our study (Table 5) is in support of those publications. With the exception of trauma death in men, both ISS and percent mortality were higher for intoxicated compared to non-intoxicated traffic-injuried.

Whereas intoxicated men with penetrating injuries (stab, firearms) showed significantly lower mortality than non-intoxicated men (8.5% vs. 12.8%), the opposite result was found in women (23.8% vs. 6.9%). Also ISS was lower in intoxicated than in non-intoxicated men, contrary to the findings in women. To our knowledge, only one earlier study, by Ward and coworkers, has suggested a "protective" effect of alcohol on trauma mortality (10). They found a non-significantly lower percent mortality in the "ethanol group" compared to the "no ethanol group" for penetrating injuries (6.5% vs. 9.8%). When we did not stratify by gender (as done by Ward), a non-significant difference between intoxicated and non-intoxicated cases was found (9.8% vs. 11.8%), similar to the findings of Ward et al. We have no good explanation for this gender-difference, but we have discussed whether stab injuries in women may represent more serious crimes, i.e. homicides conducted by men, whereas the same type of injury in men may represent a higher proportion of un-intended accidents of less serious type. We had no data to verify our hypothesis, but a separate analysis of injury intention showed a higher percent assault in women, and also a higher percentage of mortality from assault in women (data not shown).

For blunt traumas, there were no gender differences; in both genders non-intoxication was associated with significantly higher mean ISS and higher percent mortality. This corresponds to the findings in Ward's study. If the statement "the drunk can roll with the punches" is valid for any type of trauma, it is probably valid for blunt traumas.

There were no indications of higher ISS or mortality in men with signs of chronic alcohol abuse. On the contrary, markers for chronic alcohol abuse were associated with lower scores on ISS and lower percent mortality (Table 3).

In women, high values for GGT, MCV, WAM, CAGE, and SMAST were associated with increased values for both variables (Table 3). However, none of these associations were significant.

Although it is known that women suffering from chronic alcoholism experience a higher rate of mortality compared with alcoholic men (22), no other studies, at least to our knowledge, have analyzed the impact of chronic alcohol use on ISS and mortality in trauma. Because women were slightly older than men, we adjusted for age, but no substantial change in the results were seen. We are therefore tempted to suggest that also for chronic alcohol use, there seems to be a gender difference in the response to trauma.

We conclude that there were no substantial difference between acute and chronic alcohol abuse with regard to consequences of trauma. It should be noted, however, that for both types of alcohol abuse (i.e. acute and chronic) there is a sex-specific difference in its relation to morbidity and mortality. Whereas an increase in degree of alcohol abuse is followed by increase in ISS and trauma death in women, the opposite is found in men. The largest gender-difference was seen for mortality in penetrating traumas. In blunt traumas, alcohol displayed a "protective" effect, and in MV-occupants and motorcyclist, no significant effect of alcohol use was found, although a certain impairment in the measured variables was observed.

We believe that the conflicting findings in earlier studies may be attributed to the neglect of gender-specific analyses. Further, we believe that the consequences of alcohol abuse on trauma victims, differ with types of trauma.

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